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(19)

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(54) AGE-HARDENABLE ALUMINIUM ALLOY

(71) We, VEREINIGTE ALUMINIUM-WERKE AKTIENGESELLSCHAFT, a body corporate organised under the Laws of Germany, of 626 Schliessfach, Bonn, Germany, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to an age-hardenable aluminium alloy containing zinc and magnesium, suitable for use as a filler material in the fusion welding of structural parts constructed from alloys of aluminium, zinc, and magnesium.

Highly stressed welded constructions of aluminium-zinc-magnesium alloy materials, particularly those composed of the alloy AlZnMg 1, have for years been used with great success for highly diverse applications. As is well known, alloys of the type of AlZnMg 1 are characterized by a wide permissible temperature range for solution heat treatment and also by low susceptibility to quench cracking. Unlike other fusion-weldable, age-hardenable aluminium alloys, the tensile strengths of such alloys in zones affected by heat as the result of a welding process rise sharply, after an initial drop to approximately the level of the alloys in a soft-annealed or solution heat-treated condition, in consequence of re-hardening, when aged at room temperature or at elevated temperatures (for example 120—140°C) after welding. This property of the type of alloy mentioned above, although extremely important for the use of high tensile strength welded aluminium constructions, has nevertheless not previously been fully utilizable because filler materials of the same chemical composition have resulted in excessive susceptibility to welding cracks. For this reason, only the non-age-hardenable filler materials S-AlSi 5, S-AlMg 5, and S-AlMg 4.5 Mn have previously been used as filler materials, so that the weld seams have always had considerably lower tensile strengths than the other parts of a structural member welded, typically 0.2 times the limiting values.

Although various welding filler materials for aluminium-zinc-magnesium alloys have been proposed, such as, for example alloys containing 3.5 to 4.5% Mg, 1.7 to 2.8% Zn, 0.2 to 0.7% Mn, 0.06 to 0.20% Ti, and 0.08 to 0.25% Zr (all by weight), or containing 4 to 5% Zn, 3 to 4% Mg, 0.25 to 0.5% Mn, and 0.12 to 0.20% Ti (all by weight), nevertheless because of excessive susceptibility to welding cracks, inadequate tensile strength, or lack of resistance to stress corrosion cracking such filler materials have not been successful in practice. Furthermore, these filler materials usually have the disadvantage that an excessively viscous molten pool is obtained when they are used. This results in an increased risk of inadequate fusion, particularly at the side of a joint, and also to undesirable excess weld metal. The latter has, for example, a disadvantageous effect on the fatigue strength of the construction.

We have now found unexpectedly that the above-indicated shortcomings may be eliminated or substantially reduced.

According to the present invention, therefore, we provide an age-hardenable aluminium alloy comprising from 2 to 6% zinc and from 1.5 to 5% magnesium, the total of zinc and magnesium not exceeding 8.3%; from 0.1 to 0.7% chromium; from 0.05 to 1% silver; from 0 to 1% bismuth; from 0.0001

to 0.1% berylium; from 0.005 to 0.2% zirconium; less than 0.4% manganese; less than 0.2% silicon; less than 0.4% iron; less than 0.08% copper; from 0 to 1% barium; from 0 to 1% strontium; and from 0 to 1% antimony; the remainder being aluminium and any impurities resulting from manufacture.

The present alloy is particularly suitable for use as a filler material in the fusion welding of structural parts constructed from alloys of aluminium, zinc, and magnesium.

The present alloy comprises preferably from 2.5 to 4.5% zinc; preferably from 2.5 to 4.5% magnesium; preferably from 0.2 to 0.5% chromium; preferably from 0.2 to 0.5% silver; preferably at least 0.001% (more preferably from 0.002 to 0.2%) bismuth; preferably from 0.001 to 0.01% beryllium; preferably at least 0.001% barium and/or at least 0.001% strontium (more preferably from 0.002 to 0.2% barium and/or from 0.002 to 0.2% strontium); and preferably at least 0.001% (more preferably from 0.002 to 0.2%) antimony.

The following Examples illustrate the invention in tabular form:

In Table 1, the figures shown represent percentages by weight in an alloy.

TABLE 1

	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6
Zn	3.87	4.0	3.05	3.41	2.71	5.13
Mg	4.17	2.79	4.23	3.65	4.43	2.39
Ag	0.30	0.20	0.42	0.48	0.15	0.63
Bi	0.05	—	0.0025	—	—	—
Be	0.0065	0.0015	0.0040	0.0017	0.0009	0.09
Cr	0.50	0.20	0.32	0.41	0.17	0.53
Zr	0.09	0.20	0.15	0.14	0.17	0.19
Mn	0.050	0.20	<0.05	0.10	0.31	<0.05
Si	0.05	0.08	0.07	0.10	0.12	0.15
Fe	0.22	0.18	0.10	0.21	0.38	0.17
Cu	0.034	0.07	0.04	0.06	0.03	0.05
Ba	—	0.0025	—	0.13	—	0.37
Sb	—	0.0013	—	—	—	—
Sr	—	—	—	—	0.0009	—
Ti	<0.005	<0.005	0.006	0.008	0.012	0.006
Al	remainder	remainder	remainder	remainder	remainder	remainder

In order to test the properties of the present alloys the following alloys were compared in respect of tensile strength and resistance to stress corrosion cracking:

1) the known alloy A (US alloy 5180) of the following percentage composition (by weight):

Mg 3.88; Zn 1.22; Mn 0.38; Si 0.10; Fe 0.08; Cu 0.12; Ti 0.09; remainder aluminium.

2) Alloy B according to Example 1 of Table 1 above. 20 mm sheets of the alloy AlZnMg 1, consisting of

4.62% Zn; 1.24% Mg; 0.23% Mn; 0.25% Fe; 0.13% Si; 0.045% Cu; 0.13% Cr; 0.13% Zr, and 0.037% Ti; remainder aluminium, were welded by the MIG method

Half of each batch of sample was age-hardened at room temperature for three days and then for 24 hours at 120°C, and the remainder for 3 months at room temperature. Tests showed the folowing tensile values:

TABLE 2

Tensile Strength Values of Samples with eBad Machined Flush:

Filler Material	Age-hardening after welding	0.2% Proof Stress σ 0.2* kp/mm²	Tensile Strength σ B kp/mm²	Elongation on $5.65\sqrt{50}$ δ 5 %	Reduction of area on elongation ψ %
Alloy A	3 months at room temperature	20.1	30.2	6.1	20.4
	3 days at room temperature + 24 hours at 120°C	22.7	30.6	6.4	21.2
Alloy B	3 months at room temperature	24.8	33.0	7.0	22.6
	3 days at room temperature + 24 hours at 120°C	27.8	33.8	6.0	21.6

* for a measured length of 50 mm

For the purpose of investigating resistance to stress corrosion cracking, 6 mm sheets of AlZnMg 1 of which the composition is given above were welded simultaneously on both sides by the TIG method using, as filler materials, alloy A and alloy B. The welded samples were age-hardened first for 3 days at room temperature and then for 24 hours at 120°C.

The stress corrosion crack test was carried out in an aqueous solution of 2% sodium chloride and 0.5% Na_2CrO_4, adjusted with hydrochloric acid to a pH value of 3. The following life values were obtained.

Life of samples with bead machined flush

Test tensile stress kp/mm²	Filler Material	Life (days)
28	Alloy A	7
	Alloy B	more than 90
26	Alloy A	22 to 35
	Alloy B	more than 90
24	Alloy A	7 to 18
	Alloy B	more than 90

WHAT WE CLAIM IS:—

1. An age-hardenable aluminium alloy comprising from 2 to 6% zinc and from 1.5 to 5% magnesium, the total of zinc and magnesium not exceeding 8.3%; from 0.1 to 0.7% chromium; from 0.05 to 1% silver; from 0 to 1% bismuth; from 0.0001 to 0.1% beryllium; from 0.05 to 0.2% zirconium; less than 0.4% manganese; less than 0.2% silicon; less than 0.4% iron; less than 0.08% copper; from 0 to 1% barium; from 0 to 1% strontium; and from 0 to 1% antimony; the remainder being aluminium and any impurities resulting from manufacture.

2. An alloy as claimed in Claim 1 comprising from 2.5 to 4.5% zinc.

3. An alloy as claimed in Claim 1 or Claim 2 comprising from 2.5 to 4.5% magnesium.

4. An alloy as claimed in any of Claims 1 to 3 comprising from 0.2 to 0.5% chromium.

5. An alloy as claimed in any of Claims 1 to 4 comprising from 0.2 to 0.5% silver.

6. An alloy as claimed in any of Claims 1 to 5 comprising at least 0.001% bismuth.

7. An alloy as claimed in Claim 6 comprising from 0.002 to 0.2% bismuth.

8. An alloy as claimed in any of Claims 1 to 7 comprising 0.001 to 0.01% beryllium.

9. An alloy as claimed in any of Claims 1 to 8 comprising at least 0.001% barium and/or at least 0.001% strontium.

10. An alloy as claimed in Claim 9 comprising from 0.002 to 0.2% barium and/or from 0.002 to 0.2% strontium.

11. An alloy as claimed in any of Claims

1 to 10 comprising at least 0.001% antimony.

12. An alloy as claimed in Claim 11 comprising from 0.002 to 0.2% antimony.

13. An age-hardenable alloy substantially as hereinbefore described with reference to any of the foregoing Examples 1 to 6.

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